System A

Leo One USA proposes that System A use the combined downlink spectrum of NPRM System 1 and NPRM System 3. For the uplink it is proposed that the spectrum available for narrowband operation be used equally by System A and System B.

Specifically, the 400.15 - 400.505 MHz and 400.645 - 401 MHz bands (time-shared with DMSP), and the 400.505 - 400.5517 MHz band (time-shared with VITA) for downlinks; and the 150.00 - 150.05 MHz band (allocated LMSS, no sea or air use, and shared with RNSS) and the 149.81 - 149.855 MHz band (time-shared with VITA), plus the 148.905 - 149.81 MHz band (dynamically shared with Orbcomm and System B) for uplink.

- Downlink [400.15 - 400.505 MHz & 400.505 - 400.5517 MHz & 400.645 - 401 MHz]

NPRM System 1 Downlink Capacity	66 Mbits/day
+NPRM System 3 Downlink Capacity	983 Mbits/day
Total Downlink Capacity	1,049 Mbits/day
As percentage of Orbcomm capacity	90%

- Uplink [148.905 - 149.81 MHz & 149.81 - 149.855 MHz & 150.00 - 150.05 MHz]

Available uplink spectrum	
DCAAS sharing w/Orbcomm	905 kHz
+ 50% of System 1 Uplink	42.8 kHz
effectively reduced by 5% for coordination w/VITA, NPRM@46	
- 50 kHz for avoiding Orbcomm's gateway	-50 kHz
- Gateway spectrum balanced with downlink	-50 kHz
= Effective subscriber spectrum	848 kHz
x 1,160 Mbits per day / 945 kHz	1,041 Mbits/day
+ 50% of NPRM System 3 uplink capacity	94 Mbits/day
Total Uplink Capacity	1,135 Mbits/day
As percentage of Orbcomm capacity	98 %

System-A provides 90% of Orbcomm's balanced capacity and is capable of addressing Land, Maritime, and Aeronautical Mobile Satellite Services.

System B

Leo One USA proposes that System B use the downlink spectrum of NPRM System 2. For the uplink it is proposed that the spectrum available for narrowband operation be used equally by System A and System B.

Specifically, the 137.333 - 137.367 MHz and 137.753 - 137.787 MHz segments are available for 100% duty-cycle utilization after the NOAA satellites become inoperable. Use of the 137.025 - 137.175 MHz and 137.825 - 138 MHz segments must be time-shared with NOAA; and the 149.95 - 150.00 MHz band (allocated LMSS, no sea or air use, and shared with RNSS) and the 149.855 - 149.9 MHz band (time-shared with VITA), plus the 148.905 - 149.81 MHz band (dynamically shared with Orbcomm and System B) for uplink. Alternatively, System B can support a low power spread spectrum CDMA approach with the uplink operating on a shared basis with Starsys's CDMA in the 148 - 148.905 MHz spectrum or on a shared basis with System A and Orbcomm in the 148.905 - 149.81 MHz spectrum.

• Total Downlink Capacity [137 - 138 MHz] equivalent to NPRM System 2 downlink	1069 Mbits/day
As a percentage of Orbcomm capacity	92%

- Uplink [148.905 - 149.81 MHz & 149.855 - 149.9 MHz & 149.95 - 150.00 MHz]

Available uplink spectrum	
DCAAS sharing w/Orbcomm	905 kHz
+ 50% of System 1 Uplink	42.8 kHz
effectively reduced by 5% for coordination w/VITA, NPRM@46	
- 50 kHz for avoiding Orbcomm's gateway	-50 kHz
- Gateway spectrum balanced with downlink	-50 kHz
= Effective subscriber spectrum	848 kHz
x 1,160 Mbits per day / 945 kHz	1,041 Mbits/day
+ 50% of NPRM System 3 uplink capacity	94 Mbits/day
Total Uplink Capacity	1,135 Mbits/day
As percentage of Orbcomm capacity	98 %

System-B provides 92% of Orbcomm's balanced capacity and is capable of addressing Land, Maritime, and Aeronautical Mobile Satellite Services.

Orbcomm Modification

On 15 November 1994, Orbcomm filed a proposed modification to its authorized system seeking to use an additional 150 kHz of uplink spectrum in the 149.9 - 150.05 MHz band and an additional 90 kHz of downlink spectrum in the 137 - 138 MHz band, and to operate 12 additional satellites. Even without the additional satellites, this modified Orbcomm system would have more capacity then the reference standard Orbcomm system.

- Downlink [137 - 138 MHz]

Available downlink spectrum	410 kHz
-15.6% for gateway operation	-64 kHz
= Equivalent 138 MHz subscriber downlink spectrum	346 kHz
x 1,160 Mbits per day / 270 kHz	1,486 Mbits/day
Total Downlink Capacity	1,486 Mbits/day
As a percentage of Orbcomm capacity	128%

- Uplink [148.905 - 150.05 MHz]

Orbcomm capacity	1,160 Mbits/day
+NPRM System 3 uplink capacity	187 Mbits/day
Total Uplink Capacity	1,347 Mbits/day
As a percentage of Orbcomm capacity	116%

Modified Orbcomm provides 116% of Orbcomm's balanced capacity.

APPENDIX C

APPENDIX C

PROPOSED RULE AMENDMENTS TO
47 C.F.R. PART 25 OF THE COMMISSION'S RULES

§ 25.142 Licensing Provisions for the Non-Voice, Non-Geostationary Mobile-Satellite Service

(a)(4) Each applicant for a space station system authorization in the non-voice, non-geostationary mobile-satellite service must demonstrate, on the basis of the documentation contained in its application, that it is financially qualified to meet the estimated costs of the construction and launch of all proposed space stations in the system and the estimated operating expenses for one year after the launch of the initial space station, Financial qualifications must be demonstrated in the form specified in §§25.140(c) and (d). In addition, applicants relying on current assets or operating income must submit evidence of a management commitment to the proposed satellite system. Failure to make such a showing will result in the dismissal of the application.

3. Sections 25.257 and 25.258 are added to Subpart C to read as follows:

§ 25.257 Time Sharing Between NOM Meteorological Satellites and NVNG Satellites in the 137-138 MHz band

(a) An NVNG licensee time-sharing spectrum in the 137-138 MHz band shall not transmit signals into the "protection areas" of National Oceanic and Atmospheric Administration ("NOAA") satellites. The protection area shall be calculated by using ephemeris data and an earth station elevation angle of ~~zero~~ **five** degrees towards the NOAA satellite. The NVNG licensee is responsible for obtaining the necessary ephemeris data **from NOAA**. This information shall be updated system-wide on at least a biweekly basis.

(b) NVNG licensees shall establish a 24-hour per day contact person and telephone number so that claims of harmful interference into the NOAA earth stations and other issues can be reported and resolved expeditiously. This contact information shall be made available to NOAA.

(c) **NVNG satellites shall ~~be designed to cease transmission automatically if, within a forty-eight hour period, a valid reset signal has not been received from the NVNG gateway Earth station~~ establish dual redundant fail safe procedures to ensure that the satellite does not operate in a NOAA exclusion zone. All NVNG satellites shall be capable of instantaneous shutdown on any** sub-band upon command from the gateway earth station.

§ 25.258 Time Sharing Between DoD-NOAA Meteorological Satellites and NVNG Satellites in the 400.15-401 MHz band.

(a) An NVNG licensee time-sharing spectrum in the 400.15401 .O MHz band shall not transmit signals into the "protection areas" of Department of Defense ("DoD") National Oceanic and Atmospheric Administration ("NOAA") meteorological satellites. The protection area shall he calculated by using ephemeris data and an earth station elevation angle of ~~zero~~ **five** degrees toward the DoD-NOAA meteorological satellite. The NVNG licensee is responsible for obtaining the necessary ephemeris data **from DoD-NOAA**. This information shall be updated system-wide on at least a weekly basis.

(b) NVNG licensees shall establish a 24-hour per day contact person and telephone number so that claims of harmful interference into DoD-NOAA earth station users and other operational issues can be reported and resolved expeditiously. This contact information shall be made available to DoD-NOAA.

(c) NVNG satellites shall ~~be designed to cease transmissions automatically if, within forty-eight hours, a valid reset signal has not been received from the NVNG gateway earth station~~ **establish dual redundant fail safe procedures to ensure that the satellite does not operate in a DoD-NOAA exclusion zone**. All NVNG satellites shall be capable of instantaneous shutdown on any sub-band upon command from the gateway earth station.

(d) Notwithstanding other provisions of this section, NVNG satellites sharing the 400.1 S-401 MHz with DoD-NOAA meteorological satellites shall implement within ~~ninety~~ **120** minutes of receiving notice of a DoD-NOAA system fkquency change, all appropriate modifications and updates to operate on a non-interference basis in accordance with subsection (a), above.

(e) At DoD-NOAA's instruction, the Little LEO System-~~3~~ **A** operator will test, ~~up to four times~~ **at least once** a year, the Little LEO system's ability to implement a DoD-NOAA requested frequency change.

APPENDIX D

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of:	)	
	)	
Amendment of Part 25 of the Commission's	)	
Rules to Establish Rules and Policies	)	
Pertaining to the Second Processing Round	)	IB Docket No. 96-220
of the Non-Voice, Non-Geostationary Mobile	)	
Satellite Service	)	

ANALYSIS OF ELEVATION ANGLE PROTECTION REQUIREMENTS FOR THE NOM AND DMSP METEOROLOGICAL SATELLITE SYSTEMS

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December 20, 1996

ANALYSIS OF ELEVATION ANGLE PROTECTION
REQUIREMENTS FOR THE NOAA AND DMSP
METEOROLOGICAL SATELLITE SYSTEMS

I. METEOROLOGICAL EARTH STATIONS OPERATING AT 137 - 138 MHz AND 400.15 - 401 MHz SHOULD BE PROTECTED ONLY WHILE THE ASSOCIATED SATELLITES ARE LOCATED AT ELEVATION ANGLES OF FIVE DEGREES OR GREATER

Consistent with applicable functional requirements, performance factors, and international frequency sharing criteria, meteorological earth station receivers operating at 137-13 8 MHz and 401.5 - 401 MHz should be protected only while the associated satellites are located at elevation angles of five (5) degrees or greater. There generally are no functional requirements to receive "direct readout" data[1] from meteorological satellites at elevation angles less than five degrees because the associated geographic areas are too limited and distant to indicate current and evolving **meteological** conditions. Even if reception of data at lower elevation angles were desired, the received data (if any) generally would be too flawed to be of value as a result of signal degradation due to atmospheric retraction and multipath phenomena. Accordingly, a minimum elevation angle of five degrees is specified for interference and frequency sharing criteria adopted internationally for meteorological-satellite earth stations.

A. FUNCTIONAL REQUIREMENTS GENERALLY PRECLUDE ANY NEED FOR OPERATION AT ELEVATION ANGLES LESS THAN FIVE DEGREES

Real-time data transmitted by meteorological satellites may consist of soundings (e.g., atmospheric temperature profiles sampled in the nadir direction) as well as images (e.g., **raster-**

[1] **"Direct readout" data consist of the data that are collected by sensors on the satellite and transmitted in real-time.**

like infra-red sensor scans). Both types of data are needed for a large area surrounding and including the area of interest in order to deduce the current weather conditions and predict changes. To obtain these real-time data, the earth station must be located in or near the area of interest, which enables reception of data from the satellite when it is observing the area of interest and surrounding areas and it is located at high elevation angles from the earth station (e.g., above 25 degrees, which was a design objective NOAA's Automatic Picture Transmission (APT) downlinks at 137-138 MHz). Under these conditions at mid-latitudes, a constellation of two meteorological satellites would provide useful data from about seven satellite passes per day lasting about nine minutes per pass, on average. The data received from these passes is, sufficient to cover the areas surrounding the earth station at time intervals that are small enough to establish correlations between observations, which enables local forecasting to be accomplished.

Conversely, if the receiving earth station were located at a large distance from the area of interest, the satellite is visible only at low elevation angles. The time intervals between satellite passes covering the distant area of interest are relatively long, which substantially reduces the reliability of forecastings. Furthermore, the amount of data obtained for the area of interest often is too limited to infer current weather conditions, and no data are obtained for more distant areas. In the extreme case, when viewed at elevation angles between zero (0) and five (5) degrees, the meteorological satellite is observing areas located between 3,091 km (1,932 miles) and 2,576 km (1,610 miles) from the receiver location. Only two to four satellite passes per day will cover an area so far away, and the durations of satellite visibility events will often be less than two minutes (depending on the orientation of the receiver and the area of interest). Consequently, real-time data associated with receiver antenna elevation angles less than five degrees generally is not useful. There are many applications, however, where meteorological data are required for far-distant areas. These data are obtained either via communications links with receiving earth stations that are proximate to the area of interest, or from playback of data that were collected and recorded by a satellite passing over the area of interest (e.g., Command and Data Acquisition (CDA) transmissions in the 1698-1710 MHz band).

B. PERFORMANCE LIMITATIONS GENERALLY PRECLUDE OPERATION AT ELEVATION ANGLES LESS THAN FIVE DEGREES

Signal propagation phenomena occuring at low elevation angles prevent satisfactory recovery of data, as can be seen in the link power budgets presented in Tables 1 and 2 for reception at 137-138 MHz and 400.15-401 MHz, respectively.[2] Specifically, the link power margins (last row of the tables) indicate that typical earth stations often cannot receive useful data at elevation angles of five (5) or less. As explained further below, debilitating signal losses occur with high probability at low elevation angles due to multipath fading and atmosheric refraction. The magnitude of these losses vary greatly over time as the elevation angle changes; the values for these losses included in Tables 1 and 2 are expected values.[3]

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[2] The parameters given in Tables 1 and 2 for NOAA and DMSP satellites and typical earth stations are taken from Recommendations ITU-R SA. 1025- 1 ("Performance Criteria for Space-to-Earth Data Transmission Systems Operating in the Earth Exploration-Satellite and Meteorological-Satellite Services Using Satellites in Low-Earth Orbit") and ITU-R SA.10261 ("Interference Criteria for Space-to-Earth Data Transmission Systems Operating in the Earth Exploration-Satellite and Meteorological-Satellite Services Using Satellites in Low-Earth Orbit"). These parameters are identical to the parameters supplied in US contributions to the April 1993 meeting of ITU-R Working Party 7C.

[3] As the satellite ascends above the horizon and the elevation angle increases, the received signal amplitude and phase and its polarization fluctuates as the desired and multipath signal path geometries vary. At certain elevation angles in the range of zero (0) to five (5) degrees elevation, the multipath losses will be substantially higher than the expected values shown in Table 1, depending on geometric and radio parameters associated with the local environment and the earth stations.

1. <u>Surface Multipath Effects</u>

The signal received from a satellite at a low angle of elevation consist of three components: (1) a signal that travels over the direct path from the satellite to the earth station (i.e., a line-of-sight path); (2) a coherent, time-shifted replica of the signal travelling over a reflection path (i.e., the specular component of multipath); and (3) multiple, time-shifted replicas of the signal that have been scattered by the Earth surface and proximate objects (i.e., the diffie component of multipath).[4] The signals received from the multipath signal propagation mechanisms have time-varying amplitude and phase, and interfere with the direct signal in a manner referred to as multipath fading. At low elevation angles, the receiver antenna provides no significant discrimination against multipath signals, which are co-polar with the desired "direct" signal (i.e., reflection and scattering does not alter polarization orientation at grazing angles less than the Brewster angle (generally greater than six (6) degrees over land)). Thus, receivers are susceptible to the severe multipath fading that occurs at low elevation angles. The magnitude of these surface multipath signals depends on electrical characteristics of the scattering and reflecting surfaces and the signal grazing angle. Mulipath fading cannot be remedied with increased transmission power from the satellite because this equally increases the power in both the line-of-sight and interfering multipath signals.

Table 3 shows the statistics of multipath fading and underlying parameters for typical meteorological earth stations operating on medium dry ground, as determined using the method of CCIR Report 1008-l (1990). The calculated carrier-to-multipath power ratio (K) values were

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[4] **Atmospheric multipath occasionally compounds the fading arising from surface multipath, but this degradation is disregarded in this analysis. Atmospheric multipath occurs uniquely at low elevation angles during certain atmospheric conditions that generally exist for less than 10% of the time.**

used with the Nakagami-Rice distribution of the composite received signal power to obtain the cumulative time statistics of multipath fading. For elevation angles varying between zero (0) and five (5) degrees, the 80%ile values of multipath fading are the expected values.

2. Atmospheric Refractive Losses

At elevation angles less than three (3) degrees, the refractive gradient of the atmosphere exacerbates the theoretical free space spreading of the satellite signal. In effect, increased signal spreading occurs in the vertical direction at low elevation angles, which is the same phenomena that distorts the apparent shape of the sun during sunrise and sunset. The average values for this loss included in Tables 1 and 2 are taken from Section 4.2.4 of the ITU Handbook on Radiometeorology (Geneva, 1996).

C. A FIVE DEGREE MINIMUM ELEVATION ANGLE IS SPECIFIED WITH THE APPLICABLE PERFORMANCE AND PROTECTION CRITERIA

In light of the above functional requirements and performance limitations, the performance and interference criteria adopted internationally for meteorological satellite services are specified for elevation angles of five (5) degrees and higher. Specifically, for the 137-138 MHz and 400.15 - 401 MHz bands, Recommendation ITU-R SA.1025-1 specifies meteorological satellite performance objectives for 99.9% of the time that the elevation angle exceeds five (5) degrees. For protection of these transmissions, Recommendation ITU-R SA. 1026-l specifies that the total interfering signal power should not exceed certain levels during reception at elevation angles exceeding five (5) degrees. Both of these Recommendations were based on United States input documents to the ITU Working Party 7C, which were endorsed by the worlds meteorological satellite experts.

TABLE la

Link Power Budgets for Automatic Picture Transmission (137 - 138 MHz)

Elevation Angle	5°	4°	3°	2°	1°	0°
Satellite antenna input power (dBW)	4.9	4.9	4.9	4.9	4.9	4.9
Satellite antenna gain (dBic)	0.7	0.7	0.7	0.7	0.7	0.7
	5.6	5.6	5.6	5.6	5.6	5.6
Free space loss (dBW)	144.3	144.5	144.8	145.1	145.4	145.7
Surface Multipath (dB)(80%ile)	1.9	2.1	2.6	3.2	4.6	[illegible]
Refractive spreading (dB)(50%ile)	0.1	0.2	0.3	0.4	0.8	2.7
Earth station antenna gain (dBic)	2	2	2	2	2	2
Antenna mispointing loss (dB)	0	0	0	0	0	0
Polarization mismatch loss (dB)(50%ile)	1.5	1.5	1.5	1.5	1.5	1.5
Modulator and demodulator losses (dB)	2	2	2	2	2	2
Receiver reference bandwidth (kHz)	50	50	50	50	50	50
Data rate (dB Hz)	45.7	45.7	45.7	45.7	45.7	45.7
Received energy per bit (dBW/Hz) E_b	-187.9	-188.4	-189.3	-190.3	-192.4	-195.9
Receiver system noise temperature (K)	2520.	2520.	2520.	2520.	2520.	2520.
Thermal noise power density (dBW/Hz)	-194.6	-194.6	-194.6	-194.6	-194.6	-194.6
Non-thermal receiver noise power density (dBW/Hz)	-300.	-300.	-300.	-300	-300.	-300.
Total internal noise power density (dBW/Hz) N_o	-194.6	-194.6	-194.6	-194.6	-194.6	-194.6
Threshold E_b/N_o (dB)	12.	12.	12.	12.	12.	12
Power margin (dB)	-5.4	-5.81	-6.7	-7.9	8 ?	-13.3

TABLE lb

Link Power Budgets for Low Resolution Picture Transmission (137 - 138 MHz)

Elevation Angle	5°	4°	3°	2°	1°	0°
Satellite antenna input power **(dBW)**	6.8	6.8	6.8	6.8	6.8	6.8
Satellite antenna gain **(dBic)**	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
Satellite e.i.r.p. **(dBW)**	5.6	5.6	5.6	5.6	5.6	5.6
Free space loss **(dB)**	144.3	144.5	144.8	145.1	145.4	145.7
Surface Multipath **(dB)(80%ile)**	1.9	2.1	2.6	3.2	4.6	5.9
Retractive **spreading (dB)(50%ile)**	0.1	0.2	0.3	0.4	0.8	2.7
Earth station antenna gain (dBic)	2	2	2	2	2	2
Antenna mispointing loss (dB)	0	0	0	0	0	0
Polarization mismatch loss (dB)(50%ile)	1.5	1.5	1.5	1.5	1.5	1.5
Modulator and demodulator **losses (dB)**	2	2	2	2	2	2
Receiver reference bandwidth **(kHz)**	150	150	150	150	150	150
Data rate **(dB** Hz)	48.6		48.6	48.6	48.6	48.6
Received energy per bit **(dBW/Hz)** E_b	-190.8	-19183. 6)	-192.21	-193.2	-195.3	-198.8
Receiver system noise **temperature (K)**	1750.	1750.	1750.	1750.	1750.	1750.
Thermal noise power density **(dBW/Hz)**	-196.2	-196.2	-196.2	-196.2	-196.2	-196.2
Non-thermal receiver noise power density **(dBW/Hz)**	-300.	-300.	-300.	-300.	-300.	-300.
Total internal noise power density **(dBW/Hz)** N_o	-196.2	-196.2	-196.2	-196.2	-196.2	-196.2
Threshold E_b/N_o **(dB)**	6.5	6.5	6.5	6.5	6.5	6.5
Power **margin (dB)**	-1.2	-1.6	-2.5	-3.6	-5.7	-9.1

TABLE 2

Link Power Budgets for DMSP (400.15 - 401 MHz)

Elevation Angle	5°	4”	3°	2°	1°	0°
Satellite antenna input power (dBW)	11.1	11.1	11.1	11.1	11.1	11.1
Satellite antenna gain (dBic)	0	0	0	0	0	0
Satellite e.i.r.p. (dBW)	11.1	11.1	11.1	11.1	11.1	11.1
Free space loss (dB)	153.6	153.8	154.1	154.4	154.7	155
Surface Multipath (dB)(80%ile)	1.5	1.5	1.6	1.9	2.9	5.9
Refractive spreading (dB)(50%ile)	0.1	0.2	0.3	0.4	0.8	2.7
Earth station antenna gain (dBic)	0	0	0	0	0	0
Antenna mispointing loss (dB)	0	0	0	0	0	0
Polarization mismatch loss (dB)(50%ile)	0.3	0.3	0.3	0.3	0.3	0.3
Modulator and demodulator losses (dB)	2	2	2	2	2	2
Receiver reference bandwidth (kHz)	177.5	177.5	177.5	177.5	177.5	177.5
Data rate (dB Hz)	49.5	49.5	49.5	49.5	49.5	49.5
Received energy per bit (dBW/Hz) E_b	-195.9	-196.2	-196.7	-197.4	-199.1	-204.3
Re[redacted]ystem noise temperature (K)	400.	400.	400.	400.	400.	400.
Th[redacted]oise [redacted](dBW/Hz)	-202.6	-202.6	-202.6	-202.6	-202.6	-202.6
No[redacted]nal receiver noise power density (dBW/Hz)	-211.7	-211.7	-211.7	-211.7	-211.7	-211.7
Total internal noise power density (dBW/Hz) N_o	-202.1	-202.1	-202.1	-202.1	-202.1	-202.1
Threshold E_b/N_o (dB)	5.5	5.5	5.5	5.5	5.5	5.5
Power margin (dB)	0.6	0.4	-0.1	-0.9	-2.5	-7.7

TABLE 3

Calculations of Multipath Loss

Parameters:

E = elevation angle of the satellite (degrees), as seen from the earth station antenna;
φ = grazing angle (degrees), i.e., angle of arrival of signal at reflection area:
= in radians, E + $h/(a_e + h)$, where "h" is the antenna height (2 meters assumed) and a_e is the radius of the Earth;
R_o = reflection coefficient for plane Earth (numerical ratio);
g = Rayleigh roughness criteria for the surface around the reflection point (numerical ratio)(standard deviation of the surface height is assumed to be 5 meters):
= $(4\pi/\lambda)(\Delta h)\sin\varphi$, where λ is the wavelength and Ah is there standard deviation of the surface height (5 meters assumed);
D = divergence factor (numerical ratio) accounting for Earth curvature:
$\approx [1 + ((2)(h)\tan E)/(a_e)(\sin\varphi)]^{-0.5}$;
ρ_S = specular reflection coefficient (numerical ratio):
$\approx [3.2X - 2 + \{3.2X^2 - 7X + 9\}^{0.5}]^{-0.5}$, where $X = 0.5g^2$;
ρ_d = diffuse scaterring coefficient (numerical ratio)(from Figure 3 of Report 1008-1);
K = ratio of direct signal power to multipath signal power (dB):
$= 10 \log [(\rho_s)^2(D)^2(R_o)^2 + (\rho_d)^2(R_o)^2]$
L(x) = propagation loss due to multipath (dB) exceeded for all but x% of the time.

Elevation Angle (E) (degrees)		0	1	2	3	4	5
φ (deg)		0	2.03	2.5	3.3	4.26	5.21
R_o		1.00	0.94	0.87	0.81	0.76	0.72
g (137 MHz)		0.00	0.50	1.00	1.51	2.01	2.51
g (401 MHz)		0.00	1.47	2.93	4.40	5.86	7.32
D		1.00	1.00	1.00	1.00	1.00	1.00
ρ_s (137 MHz)		1.00	0.88	0.64	0.43	0.31	0.24
ρ_s (401 MHz)		1.00	0.44	0.20	0.13	0.10	0.08
ρ_d (137 MHz)		0.00	0.19	0.32	0.41	0.39	0.38
ρ_d (401 MHz)		0.00	0.37	0.28	0.21	0.14	0.07
137 - 138 MHz	K (dB)	0	1.4	4.1	6.3	8.4	9.8
	L(50)	1.5	1.4	1.2	0.9	0.8	0.8
	L(80)	5.9	4.6	3.2	2.6	2.1	1.9
	L(90)	9.6	7.2	5.6	3.7	3.2	3.1
400.15 - 401 MHz	K (dB)	0	5.3	10.5	14.0	17.7	22.3
	L(50)	1.5	1.1	0.8	0.5	0.5	0.5
	L(80)	5.9	2.9	1.9	1.6	1.5	1.5
	L(90)	9.6	4.6	3.1	2.5	2.4	2.2

DECLARATION

I. Thomas M Sullivan, do hereby declare as follows:

1 I have a Bachelor of Science degree in Electrical Engineering and have taken numerous post-graduate courses in Physics and Electrical Engineering.

2 I presently operate a consulting company. Sullivan Telecommunications Associates, and was formerly employed by the IIT Research Institute, DoD Electromagnetic Compatibility Analysis Center; the Computer Sciences Corp.; and American Mobile Satellite Corp.

3 I received in 1982 an official commendation from the Department of the Army for the establishment of worldwide frequency accommodations for mobile earth stations.

4 I am qualified to evaluate the technical information in the Comments of LEO One Corporation. I am familiar with Part 25 and other relevant parts of the Commission's Rules and Regulations.

5. I was a principal engineer in the development of the Phase A design and technical specifications of the data handling and transmission subsystems of the 137 - 138 MHz Low Resolution Picture Transmission (LRPT) system to be flown on U.S./NOAA and European/EUMETSAT satellites in low-Earth orbit before the year 2010.

6. I served as the principal engineer and author of U.S. contributions to ITU-R Working Party 7C on the performance, interference and sharing criteria of NOAA and DoD meteorological-satellite downlinks (APT, TIP, LRPT, and DMSP) operating at 137 - 138 MHz and 400.15 - 401 MHz, and I worked closely with NOAA and Air Force personnel to ensure that these contributions accurately portrayed the technical and operating characteristics of these systems.

7 I have been involved in the preparation and have reviewed the Comments of LEO One Corporation The technical facts contained therein are accurate to the best of my knowledge and belief

Under penalty of perjury, the foregoing is true and correct.

December 17, 1996 — Thomas M. Sullivan

Date — Thomas M. Sullivan

APPENDIX E

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RESPONSES TO TECHNICAL QUESTIONS FROM NOTICE

I. Sharing with NOAA MetSat program in 137-138 MHz Band

A. Concurrent time sharing of TIP channels and LRPT channels.

B. Impact to NOAA community of Little LEO transmissions when NOAA satellites are not in view.

C. 48 hour reset signal is unnecessary.

D. MetSat Earth Stations operating at 137-138 MHz should be protected only while the associated satellites are located at elevation angles of five degrees or greater.

II. Sharing with DMSP MetSats in 400.15-401 MHz band

A. DMSP Earth Stations operating in the 400.15-40 1 MHz band should be protected only while associated satellites are located at elevation angles of five degrees or greater.

B. NVNG MSS System Testing Requirements

C. 90 Minute Command Station Requirements

D. Transitional Interference Statistics

1. "Fence" site results

2. "90 Minute" site results

E. Accurate Ephemeris Prediction

III. Sharing with the Radio Navigation Satellite Service

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RESPONSES TO TECHNICAL QUESTIONS FROM NOTICE

I. Sharing with NOAA MetSat Program in the 137 - 138 MHz Band

The NOAA MetSat band can be shared on a non-interference basis to NOAA using a frequency avoidance concept. This simplified frequency sharing concept requires the Little LEO satellites to step or hop to the opposite NOAA MetSat band segment whenever a NOAA MetSat satellite coverage footprint overlaps that of a Little LEO satellite horizon. The coincidence times are readily precomputed and frequency selection instructions can be loaded into each satellite to span the duration of element set validity.

It should be noted that for a multiple satellite NOAA NPOESS system, the potential exists for two NOAA coverage zones to overlap a Little LEO horizon footprint over CONUS as shown in Figure 1. These coverage contours were obtained by using five of the NOAA satellites currently in orbit as representative of future orbital coverage. This overlap will result in total blockage of the Little LEO System in those areas where the dual NOAA overlap occurs. Worse still, any two NOAA satellites within the horizon coverage of a Little LEO satellite will potentially result in a blockage situation. This worse case analysis assumes the two NOAA MetSats in close proximity will use both portions of the bands or channels so as not to interfere with themselves, leaving a Little LEO without any available spectrum during this overlap period.

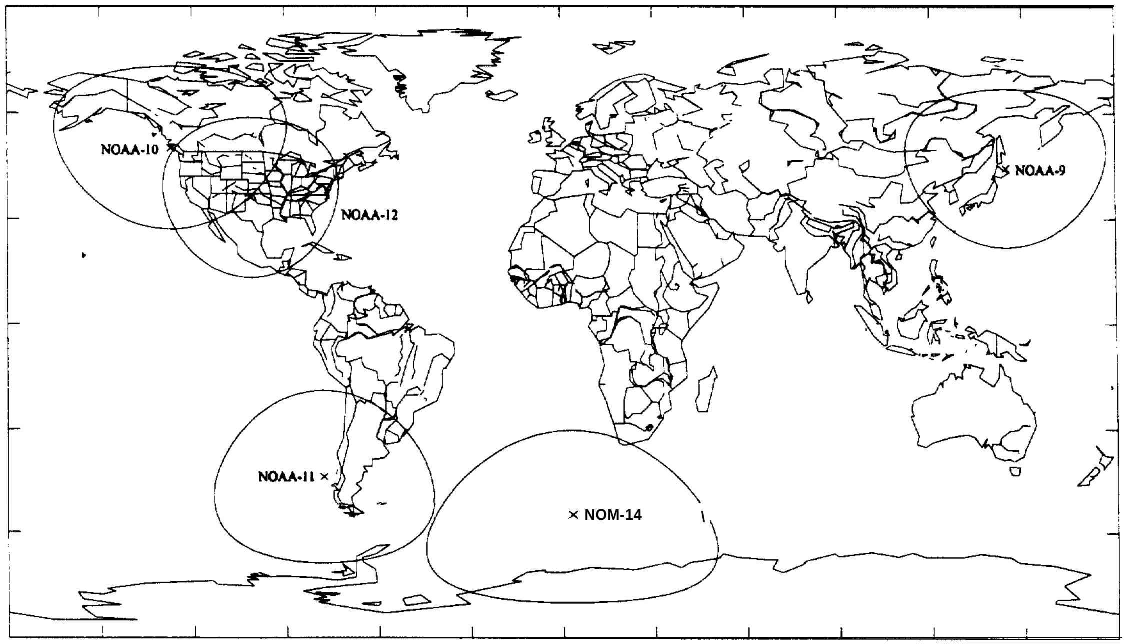

Figure 1. Five Satellite NOAA Constellation Coverage For 5° Elevation Footprint.

Figure 2 is a plot of Leo One USA's availability calculated for sharing of the NOAA bands or channels with a 2, 3, 4 or 5 POES satellite constellation. The NOAA-14, NOAA-12, NOAA-1 1, NOAA-IO, and NOAA-9 satellites were used for this availability calculation. The NOAA-14 (137.620 MHz) and NOAA-12 (137.500 MHz) satellites being the current two AM & PM operational satellites. The others are currently in standby and are used in the order listed as representative of future NOAA constellation growth. NOAA-K is planned to replace NOAA-12 in August 1997. The launch dates for the planned replacement satellites are NOAA-L (PM) in Dec. 1999, NOAA-M (PM) in April 2001, NOAA-N (PM) in Dec. 2003 and NOAA-N' (PM) in July 2007. These last two N-series satellites being the new LRPT band satellites. The European METOP-1 and -2 satellites are planned as AM satellites for 2002 and 2006 and will use the new LRPT bands.

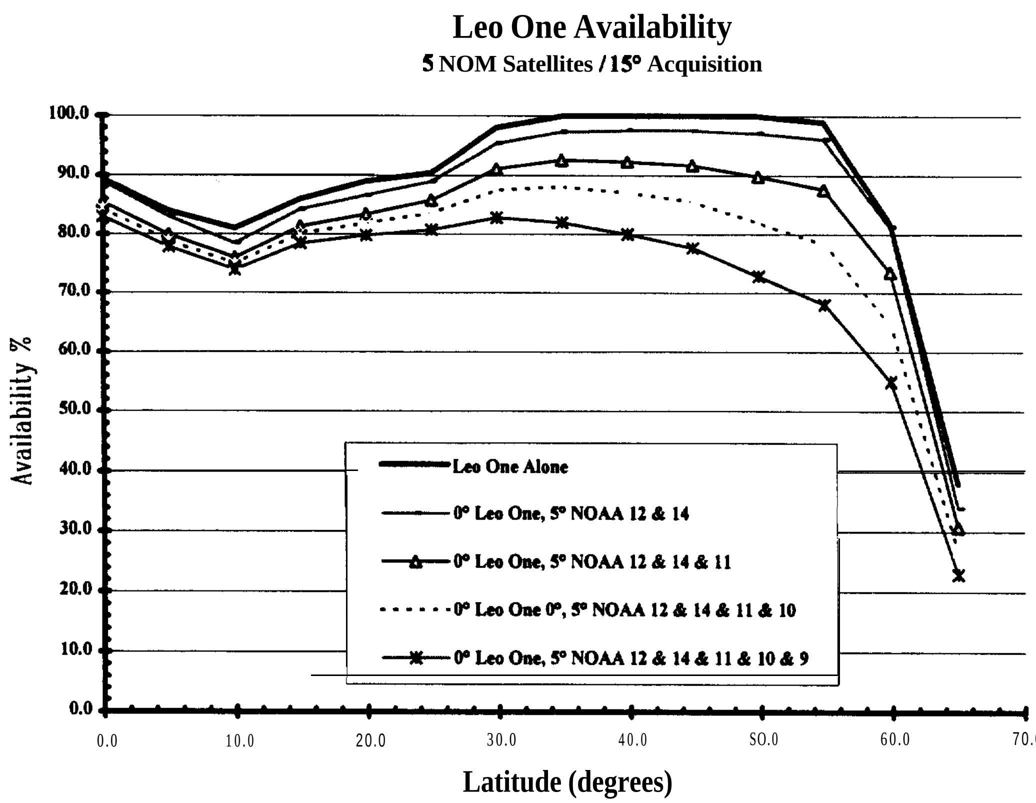

Figure 2. Availability As A Function of The Number Of NOAA Satellites.

The current Meteor-3 series of Russian MetSats may cause some interference at the edges of the TIP channels. Likewise, the China FY-1B satellite currently overlaps the upper TIP NOAA channel and also the lower LRPT band. For this analysis, it is assumed that availability degradation is insignificant.[1] Russia has indicated that beginning with its second Meteor 3M series it will transition to the LRPT bands[2]. The first Meteor 3M satellite will continue to use the existing Russian channels at 137.30, 137.40, and 137.85 MHz. The Meteor 2 system previously used 137.15 MHz instead of 137.85 MHz. Their continued use of the 137.30, 137.40, and 137.85 MHz bands after their transition to the

1 This cannot be verified. It is assumed that these systems would transmit worldwide.

2 Russian Fax OMPZ-50-06967 to FCC Notifications Branch Dated July 1995.